GBM auction versus English auction: a large-scale empirical study

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1 Abstract

Until recently, no empirical study of the novel Gonnaud–Bessire–McDonaugh ("GBM") auction had been conducted. In this paper, we analyse the bidding data of the first large-scale implementation of the GBM auction, which was carried out by the blockchain video game Aavegotchi in August 2021. The sale event included 12,001 simultaneous auctions of comparable items, sold through four different types of GBM auctions and English auctions, distributed pseudo-randomly. This created optimal conditions to study and compare these auction types. We first analyse how GBM auctions of different parameters compare to the English auction in terms of bidding behaviours, sale price and auction revenue. We find that, in effect, a GBM auction has a higher first bid, higher bids overall, a higher selling price, a higher revenue for the seller, fewer bids and take less time to reach its final bid than an English auction — all other things being equal. We then compare GBM auctions of different parameters with each other and find that a GBM auction with higher incentives has a higher first bid, higher bids overall, a higher selling price and fewer bids than a GBM auction with a lower incentive function — all other things being equal.

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2 Introduction

2.1 The GBM Auction

A Gonnaud–Bessire–McDonaugh ("GBM") auction[1] is an open ascending auction in which bidders are paid an incentive when they are outbid. As a result, a GBM auction participant either wins the auction or leaves with more money than they started with.

From a starting bid [1], each new bid needs to be higher than the previous bid by a minimum step. When a bidder is outbid, he is paid an incentive in addition to being refunded the full amount of their bid. This incentive is a percentage of their bid calculated using an incentive function, which depends on the value of the previous standing bid and other variables. The auction is time-limited, and the highest bidder at the end of the auction wins. Additional time is added when a new bid is placed towards the end of the auction. All bids are public. The revenue of the auction (going to the seller) is equal to the final bid minus the sum of the incentives distributed to losing bidders.

In this sale that is the object of our study, the incentive function used was g, which takes as parameters the previous standing bid x and the new standing bid y, and returns the incentive that a new bidder will receive when they are outbid, as a percentage of the value of the new standing bid:

$g : (x, y) \longrightarrow min \left[\; inc_{max} \; , \; inc_{min} + a \times \frac{y - x(1+step_{min})}{x(1+step_{min})} \; \right]$ for $x > 0$ and $g(0, y) = inc_{max}$

with

- x : the previous standing bid.
- y : the new bid which is going to replace the standing bid.
- inc_{max} : the maximum incentive, expressed as a percentage of the new bid amount.
- inc_{min} : the minimum incentive, expressed as a percentage of the new bid amount.
- a : the accelerator, expressed as a positive real number. It controls the growth of the percentage incentive, relative to the ratio between the previous standing bid and the new bid.
- $step_{min}$: the minimum bid increment, expressed as a percentage of the previous standing bid.

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[1] The starting bid is defined by the seller and can be 0.

2.2 Context

The GBM auction was introduced in 2018[2] and first implemented in 2020 for the sale of NFTs on the Cryptograph marketplace[3], but until recently there was no large-scale implementation of the system that would allow a comparison of different implementations of the GBM auction and a traditional English auction in similar real-life conditions.

In August 2021, blockchain video game Aavegotchi[4] implemented the largest GBM auction event at the time[5], which took place online over 3 days on Aavegotchi's own website, and included the sale of 12,001 portals and 13,945 digital wearables all sold through simultaneous GBM and English auctions. In this paper, we only study the 12,001 portals auctions.

2.3 Key Research Questions

The aim of this study is to assess whether the following 6 assertions are verified empirically:

1. A bidder will place a higher bid in a GBM auction than in an English auction, all other things being equal, and the higher the GBM incentive function, the higher the bid will be.
2. A GBM auction leads to a higher selling price (final bid) than an English auction, all other things being equal, and the higher the GBM incentive function, the higher the selling price.
3. A GBM auction nets more revenue (after incentives are distributed to bidders) for a seller than an English auction, all other things being equal, and the higher the GBM incentive function, the higher the revenue.
4. A GBM auction has fewer bids than an English auction, all other things being equal, and the higher the GBM incentive function, the less bids a GBM auction has.
5. The first bid in a GBM auction is higher than in an English auction, all other things being equal, and the higher the GBM incentive function, the higher the first bid.
6. The selling price (final bid) is reached faster in a GBM auction than in an English auction, all other things being equal, and the higher the GBM incentive function, the faster the selling price is reached.

3 Method

3.1 Auctions Conditions

All 12,001 portal auctions started on August 26th at 2pm (UTC) and most ended after 72 hours on August 29th at 2pm (UTC), although a small portion of auctions were extended by up to 3 hours[2].

The currency used in these auctions was the native currency of the Aavegotchi game: GHST. As such, all bids and bidding data gathered were in the GHST currency. At the time of the event, GHST had a market value of around 1 GHST = 2-2.15 USD [6].

Several characteristics of this sale created optimal conditions to test assertions related to the GBM auction model:

- The event included the simultaneous sale of Aavegotchi portals which were auctioned ”unopened”, thus all portals sold were identical with the only differentiating factor between them being the portal’s unique $tokenID$ and the auction parameters.
- The number of portals auctioned (12,001) was high enough to be able to draw insights from our results with reasonable confidence.
- Four different types of GBM auctions as well as English auctions were distributed pseudo-randomly by $tokenID$, so results can be compared between auction types.
- The auctions were ran on the Polygon blockchain[7], with all bids being fully-funded, public, and incentives distributed to bidders in real-time during the auction.
- The user interface was designed specifically for this sale, and allows bidders to browse auctions, search them and filter them by $tokenID$ and auction type, and see this information on each portal’s bidding page.

3.2 Auction Presets

Five different variations of the auction parameters (”presets”) were used:

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[2] If a bidder placed a bid in last 20 minutes of the end of an auction, that auction was extended for up to 20 minutes through a feature of the GBM auction called Hammer time.

Preset	inc_{min}	inc_{max}	a	$step_{min}$
English	0 %	0 %	0	5%
Low	0.5 %	5 %	0.0508	5%
Medium	1 %	10 %	0.1125	10%
High	1.5 %	15 %	0.187	15%
Degen	3 %	30 %	0.4874	30%

Table 1: GBM parameters of the auction presets

An English auction being a GBM auction with $inc_{min} = inc_{max} = 0$ [1], we then chose $step_{min} = 5\%$ for the English preset so it is equal to the $step_{min}$ of the Low preset for better comparison.

The values of a were chosen such that the highest incentive percentage returned by g is reached when the new bidder places a bid twice as high as the previous bid. The main reasons for this choice were that it was simple to communicate (i.e. *"You must double the current bid to get the maximum % return on your bid"*), and that it seemed to be a good compromise between increasing the speed of convergence to the final price and reducing the percentage of the selling price that is distributed to bidders as incentives. The values of a were then rounded up for each presets very slightly to account for rounding display errors on Aavegotchi's website.

The Degen preset has a very high return function on purpose, and was created to be used only for auctions of portals with special *tokenIDs* that are later excluded from this study.

3.3 User Interface

Bidders were able to browse and access all auctions from the Open Auctions page, and combine filter and sort functions to look for specific auctions.

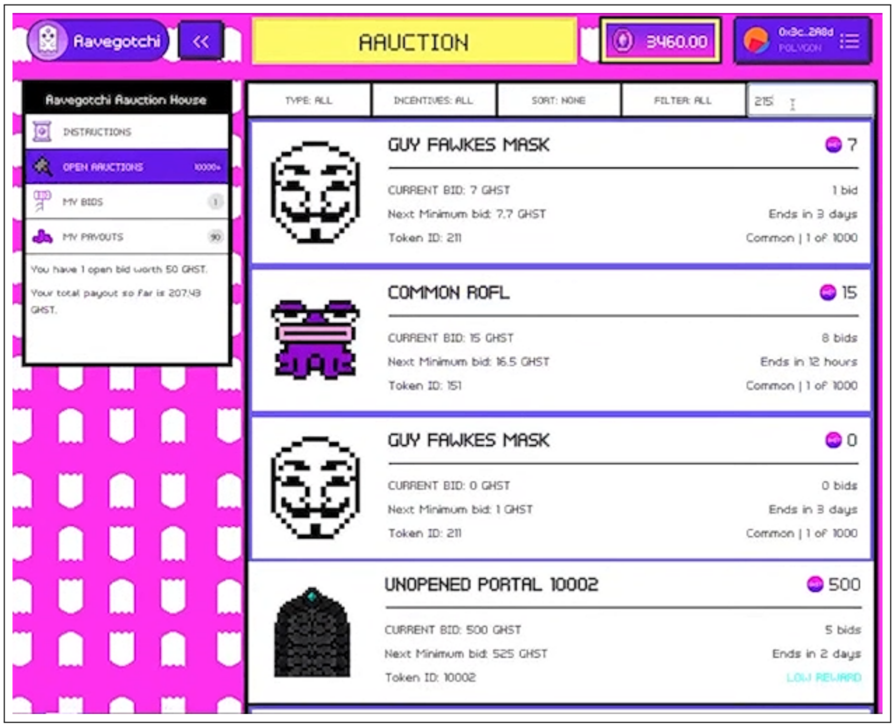
Bidders were able to filter auctions by:

- item type, so as to only display portals or only wearables
- auction preset, so as to only display certain types of auctions (e.g. only display auctions with the "High" GBM preset) and easily access them
- tokenID, to only display specific portals or a specific type of wearables

Bidders were able to sort auctions by:

- Most recent bid
- Cheapest current bid
- Most expensive current bid
- Time left in the auction

Finally, bidders could see the number and value of their active bids, as well as how much they had earned in incentives in real time.



TYPE: ALL | INCENTIVES: ALL | SORT: NONE | FILTER: ALL | 215

You have 1 open bid worth 50 GHST.

Your total payout so far is 207.43 GHST.

GUY FAWKES MASK 7
CURRENT BID: 7 GHST 1 bid
Next Minimum bid: 7.7 GHST Ends in 3 days
Token ID: 211 Common | 1 of 1000

COMMON ROFL 15
CURRENT BID: 15 GHST 8 bids
Next Minimum bid: 16.5 GHST Ends in 12 hours
Token ID: 151 Common | 1 of 1000

GUY FAWKES MASK 0
CURRENT BID: 0 GHST 0 bids
Next Minimum bid: 1 GHST Ends in 3 days
Token ID: 211 Common | 1 of 1000

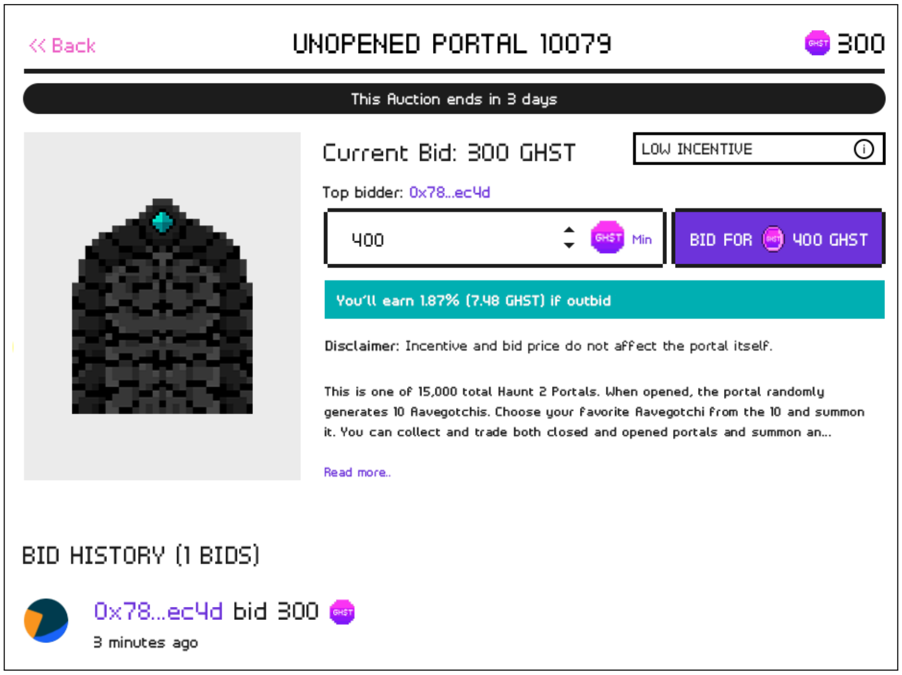
UNOPENED PORTAL 10002 500
CURRENT BID: 500 GHST 5 bids
Next Minimum bid: 525 GHST Ends in 2 days
Token ID: 10002 LOW REWARD

Figure 1: Open Auctions page

When a bidder clicked on an auction from the Open Auctions page, they were taken to the Bidding page of that auction. The Bidding page information included:

- Item Name e.g. ”UNOPENED PORTAL 10079”
- Time left in the auction e.g. ”3 days”
- Current Bid e.g. ”300 GHST”

- Top Bidder e.g. ”0x78...ec4d”
- Auction Preset e.g.”Low Incentive”
- % incentive if outbid (if a number is input in the bid field)
- Absolute incentive in GHST if outbid (if a number is input in the bid field)
- Description of the item



This Auction ends in 3 days

Current Bid: 300 GHST

Top bidder: 0x78...ec4d

You’ll earn 1.87% (7.48 GHST) if outbid

Disclaimer: Incentive and bid price do not affect the portal itself.

This is one of 15,000 total Haunt 2 Portals. When opened, the portal randomly generates 10 Aavegotchis. Choose your favorite Aavegotchi from the 10 and summon it. You can collect and trade both closed and opened portals and summon an...

0x78...ec4d bid 300

3 minutes ago

Figure 2: Bidding page

3.4 Presets Distribution

As the Aavegotchi portals were auctioned ”unopened”, they were all identical with the only differentiating factor between them being the portal’s unique *tokenID*. At first sight, this could have meant that the auction presets could be distributed randomly among the different auctions. However, previous observations showed that Aavegotchi users attribute significantly higher value to an item if its *tokenID* is a special number e.g. round, repeating, palindromic.

As a result, these special numbers were identified and attributed the Degen auction preset, and are then excluded from our study. The list of special *tokenIds* is 101 strong, as follows:

{10000, 11000, 12000, 13000, 14000, 15000, 16000, 17000, 18000, 19000, 20000, 21000, 22000, 21999, 11111, 12221, 13331, 14441, 15551, 16661, 17771, 18881, 19991, 20002, 21112, 12321, 13431, 14541, 15651, 16761, 17871, 19891, 21012, 10101, 10201, 10301, 10401, 10501, 10601, 10701, 10801, 10901, 11211, 11311, 11411, 11511, 11611, 11711, 11811, 11911, 21212, 21312, 21412, 21512, 21612, 21712, 21812, 21912, 20102, 20202, 20302, 20402, 20502, 20602, 20702, 20802, 20902, 21998, 11011, 12012, 13013, 14014, 15015, 16016, 17017, 18018, 19019, 20020, 21021, 10001, 11001, 12001, 13001, 14001, 15001, 16001, 17001, 18001, 19001, 20001, 21001, 10999, 11999, 12999, 13999, 14999, 15999, 16999, 17999, 18999, 19999}

After the attribution of the Degen auction preset to the 101 ”special” *tokenID*s, the following distribution of preset was applied to the remaining auctions:

- $\simeq$ 10% of English auctions
- $\simeq$ 30% of auctions with preset Low
- $\simeq$ 30% of auctions with preset Medium
- $\simeq$ 30% of auctions with preset High

To that effect, we created our own pseudo-randomized function that multiplied the *tokenID* by a large prime number, performed a modulo check and returned a preset for a given *tokenID* following the above probability distribution. This was done because existing random functions would be too costly to run on a blockchain, which is where the auction preset attribution was executed. After execution, the presets distribution was as follows:

- 1190 English auction
- 3571 GBM auctions with Low preset
- 3569 GBM auctions with Medium preset
- 3570 GBM auctions with High preset
- 101 GBM auctions with Degen presets (for the special *tokenId*s)

3.5 Data Collection

The raw bidding data is public on the Polygon blockchain and can be accessed by reading the transactions of the Aavegotchi smart contract used for this sale on the Polyscan explorer [8]. The bidding data was retrieved from Aavegotchi’s subgraph on The Graph protocol, stored and sanitized in MongoDb, and then imported as a CSV into a spreadsheet and analysed to generate our results. Two other data set were also created and imported into that same spreadsheet to get additional data on rejected bids and information about the bidders which are not stored on the blockchain.

For each auction, we captured the following on-chain data:

- id: the auction identifier
- $tokenID$: the serial number of the portal being auctioned;
- $highestBid$: the current highest bid of the auction
- $highestBidder$: the bidder's address who placed the highest bid
- $auctionStartTime$: the time and date the auction started i.e. bidding opened;
- $auctionEndTime$: the time and date the auction ended i.e. bidding closed;
- $IncMin$: the parameter inc_{min}
- $IncMax$: the parameter inc_{max}
- $accelerator$: the parameter a
- $stepMin$: the parameter $step_{min}$
- $gbmPreset$: the GBM preset for the auction (none, low, medium, high or degen)

For each bid, we captured the following on-chain data:

- $auctionID$: the auction identifier where the bid iss placed
- $tokenID$: the serial number of the portal being bid on;
- $bidder$: unique user identifier (the wallet address used to bid);
- $amount$: the amount of the bid;
- $auctionTimeLeft$: number of seconds left until the end of the auction;
- $bidChainTime$: the timestamp when the bid is accepted or rejected on chain;
- $bidWebsiteTime$: the timestamp when the bidder placed the bid on the Aavegotchi website (i.e. click the final confirmation button);
- $bidderBalance$: the amount of GHST token in the bidder's wallet (excluding the bid);
- $transationFees$: the transaction fees linked to the bid on Polygon

- *standingBid* : the amount of the standing bid when the bidders places the bid on the website.

For each incentive, we captured the following on-chain data:

- *auctionID*: the auction identifier where the bid is placed
- *tokenID*: the serial number of the portal where the incentive is distributed;
- *earner*: unique user identifier (the wallet address used to bid);
- *amount*: the amount of the bid;
- *receiveTime*: the timestamp when the incentive is distributed to the bidder;

For each rejected bid, we captured the following data from the website:

- *bidderAddress*: unique user identifier (the wallet address used to bid);
- *bidDate*: the timestamp when the bidder attempted to place his bidin;

For each bidder, we captured the following data:

- *bidderAddress*: unique user identifier (the wallet address used to bid);
- *TotalBiddingVolume*: the total quantity of money (in GHST) placed by the bidder
- *NumberOfBids*: the total number of bids for the whole drop
- *NumberOfTimeOutbid*: the number of time the bidder is outbid for the whole drop
- *TotalPayoutAmount*: the total earned by the bidder (in GHST)
- *NumberOfPayouts*: number of times the bidder got incentives
- *Win*: the number of auctions won by the bidder
- *numberAavegotchis*: number of Aavegotchi owned before the drop

For transparency and to encourage further research, we have made available the entire sanitised data set and computed results at the following link:
https://docs.google.com/spreadsheets/d/1BExLjJ8o4rp47GxkRYWh1H0bwqL4tuo24nTZ92eDhz4/edit?usp=sharing

4 Results

4.1 Bid Amounts

We computed the average bid amount in GHST for each auction preset.

	English	**Low**	**Medium**	**High**
Average bid per auction	161.46	230.64	232.35	341.32

Table 2: Bid Amounts

4.2 Revenues

We computed the average revenue in GHST for each auction preset.

	English	**Low**	**Medium**	**High**
Average revenue per auction	309.1	355.74	329.39	539.66

Table 3: Revenues

4.3 Number of Bids

We computed the total and average number of bids per auction preset.

	English	**Low**	**Medium**	**High**
Number of bids	11,525	26,306	15,199	14,170
Average bids per auction	9.68	7.37	4.26	3.97

Table 4: Number of Bids

4.4 Time to Final Bid

We computed the average time to reach the final bid for each auction preset.

	English	**Low**	**Medium**	**High**
Average time to final bid	41h 26m	50h 30m	31h 13m	6h 39m

Table 5: Time to Final Bid

4.5 First Bids Amount

We computed the average amount of the first bid in GHST for each auction preset.

	English	**Low**	**Medium**	**High**
Average first bid	63.78	93.12	132.88	164.83

Table 6: First Bids Amount

4.6 Selling Prices (Final Bids)

We computed the average amount of the final bid in GHST for each auction preset.

	English	**Low**	**Medium**	**High**
Average final bid	351.96	378.39	362.62	605.43

Table 7: Selling Prices (Final Bids)

4.7 Multi-auction Bidders

For each pair of auction presets, we selected only the bids from bidders who placed bids on at least one auction of each of the two presets in that pair. Then, we calculated the average of these selected bids for each of the auction preset.

	English	**Low**	**Medium**	**High**
English	N/A	200.89	211.64	211.07
Low	241.97	N/A	232.80	252.26
Medium	263.84	252.63	N/A	247.29
High	334.24	339.14	320.61	N/A

Table 8: Average bids of multi-auction bidders

The above table is read as follows: The rows represent the type of auction where the average bid amount is computed and the column indicates the other auction type the bidder participated in i.e. the value in the cell (English, Low) is the average bid placed in an English auction by bidders who also placed bids on at least one Low auction. This number is to be compared to the value in the cell (Low, English), which shows the average bid placed by the same bidders in the Low auctions. For legibility, the cells that belong to the same pair and should be compared have been colorised with the same color.

4.8 Multi-auction Winners

For each pair of auction presets, we then selected only the winning bids from bidders who placed winning bids on at least one auction of each of the two presets in that pair. Then, we calculated the average of these selected winning bids for each of the auction preset. The table below is read in the same way as Table 8.

	English	**Low**	**Medium**	**High**
English	N/A	369.37	360.70	389.10
Low	370.02	N/A	376.47	464.15
Medium	355.17	366.92	N/A	390.05
High	590.75	597.45	579.00	N/A

Table 9: Average winning bids of multi-auction bidders

5 Discussion

Proposition 1: A bidder will place a higher bid in a GBM auction than in an English auction, all other things being equal, and the higher the GBM incentive function, the higher the bid will be.

In Table 2, we can already observe that the average bid for the English auction is 161.46 GHST whilst the average bids for all GBM presets are significantly higher, from 230.64 GHST for the Low preset to 341.32 GHST for the High preset.

However, the results in Table 8 go further, and allow us to directly compare the value that only bidders who placed bids on different auction presets attributed to portals solely based on which preset they were sold with, all other things being equal. We find that in every single pair of preset that includes English auction, the same bidder will place a higher bid in a GBM auction than in an English auction for the same item. For a bidder who places bids in both English auction and Low auction, his average bid amount was 200.89 GHST for the English auction and 241.97 GHST for the Low auction. The difference becomes more significant for the GBM auction with High presets. Indeed, for a bidder who placed bids in both English auction and High auction, his average bid amount was 334.24 GHST for the High auction and 211.07 GHST for the English auction, thus he placed in average a bid 1.6 times higher for the High auction, which is notable.

As per the impact of the GBM parameters on the bid values, we also clearly observe that the higher the incentives distributed to the bidders, the higher the bids are. For each pair of GBM auction, the average bid amount placed for the GBM auction with the higher incentives is always greater than the one placed for the other GBM auction preset. For instance for both Medium and High auctions, a bidder placed in average 320.61 GHST for the High auction, and 247.29 GHST for the Medium auction.

To see if this hypothesis is also verified when considering only the winning bids of bidders who won more than one type of auction, we look at Table 9. However, it is important to note that there were not many such bidders and bids, hence these results carry less weight than the ones from Table 2. We find that for a bidder who won in more than one auction type, the results are almost identical for the English auctions, Low and Medium auctions. A net difference starts showing only once comparing with the High GBM preset. Indeed, for the High preset the average winning bid of bidder who won more than one type of auction is between 579-597.45 GHST, compared to 389.10-464.15 GHST for the other auctions in the pair with High.

Proposition 2: A GBM auction leads to a higher selling price (fi-

nal bid) than an English auction, all other things being equal, and the higher the GBM incentive function, the higher the selling price.

Looking at the results of Table 7, we find that the average final bid for GBM auctions ranges between 362.62 for Medium and 605.43 GHST for High, higher than the 351.96 GHST for the English auction.

As per the impact of the GBM parameters on the final bid, except for the Medium preset, the average final bids increase with the growth of incentives. However, we observe, as we did in Table 9, that Low and Medium auctions got a similar selling price, of roughly 370 GHST. It is within the High auction that the final bids soared, with almost double of what we observe with the English auction, to reach a final bid of 605 GHST in average.

Proposition 3: A GBM auction nets more revenue (after incentives are distributed to bidders) for a seller than an English auction, all other things being equal, and the higher the GBM incentive function, the higher the revenue.

Table 3 shows that the average revenue of GBM auctions is higher than the average revenue of the English auction, especially again when looking at the High auction preset, with an average revenue of 540 GHST, which is 230 GHST higher than the average revenue generated by an English auction (309 GHST). When comparing the GBM presets, it should be noted that the average revenue is not a non-decreasing function of the incentives distributed to the bidders as we could have expected, because of the results of the Low and Medium presets. In other words, higher incentives may generate more or less revenues. For instance, we see that the average revenue per auction for the Medium auction preset is less than the average revenue generate with the Low auction preset.

Proposition 4: A GBM auction has fewer bids than an English auction, all other things being equal, and the higher the GBM incentive function, the less bids a GBM auction has.

Table 4 clearly shows that the average number of bids is lower for a GBM auction than an English auction, and that this number decreases as the GBM incentive function increases.

Proposition 5: The first bid in a GBM auction is higher than in an English auction, all other things being equal, and the higher the GBM incentive function, the higher the first bid.

The results from Table 6 show a clear increase in first bid amounts between the English auction and the GBM auction, as well as between GBM auctions (around 30 GHST more each time we move to the next preset in the table). The average first bid amount is 50% bigger in Low preset auctions than in English auction, and 158% more in High preset auctions than in the English auctions. The High preset auctions have a first bid almost double the amount of the Low auctions on average, which is also very significant when comparing GBM presets with each others.

Proposition 6: The selling price (final bid) is reached faster in a GBM auction than in an English auction, all other things being equal, and the higher the GBM incentive function, the faster the selling price is reached.

Table 5 shows that the Medium and High preset auctions did reach their final price much faster than the English auctions, with 31 hours for the Medium auction, and 6 hours and 40 minutes for the High auction compared to roughly 41 hours and a half for the English auction. This is a outstanding difference, as the High auction reached in average its final bid 6 times faster than the English auction. This seems to clearly validates the hypothesis that the selling price is reached faster in a GBM auction than in an English auction. However, surprisingly, we can see that the Low auctions took on average 50 hours and a half to reach their final bid a 20% increase compared to the English auction.

6 Conclusion

Through the investigations carried out in this study, we find that most of the propositions we have laid out in 2.3 are verified empirically. Indeed, we observe that, in effect, a GBM auction *(1)* has a higher first bid, *(2)* has higher bids overall, *(3)* has a higher selling price, *(4)* has a higher revenue for the seller, *(5)* involves fewer bids, and *(6)* takes less time to reach its final bid compared to an English auction — all other things being equal.

Furthermore, most of these propositions are also verified when comparing GBM auctions across a range of various incentive tuning: a GBM auction with higher incentives has a higher first bid, higher bids overall, a higher selling price and fewer bids than a GBM auction with a lower incentive function — all other things being equal. On the flip side, the data collected throughout the studied large-scale experiment does not allow us to conclude with convincing statistical significance that higher incentives lead the GBM auction to more revenue and less time to reach the final bid. We believe that this is due to said sale event having too many auction presets and the gap between them being too small — hence displaying poor data diversity and coverage. Namely, the Low preset may have been offering too little return to be attractive, whilst not being set apart enough from the Medium preset.

The results we laid out in this report are striking, and attest to the significant advantages the GBM auction holds over the traditional English auction — both for the seller and the bidders. Even though, this study remains the first of its kind and a lot more research is needed to gauge the effect that the various actors might cause in the GBM auction. There is a lot that is still unknown about what influences bidding behaviour and selling prices. We hope that this study will pave the way for the incipient and soon widespread use of the GBM auction model.

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